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Command Uplink Budget

2014-07-14 M.K

SSOSAT/mo-76

$$P_r = P_t + G_t + G_r + 169.54 - 20 \log(f) - 21.98 - 20 \log R$$

$$= P_t + G_t + G_r + 147.56 - 20 \log(437.505 \times 10^6) - 20 \log R$$

$$= P_t + G_t + G_r + 147.56 - 172.82 - 20 \log R$$

$$= \underbrace{P_t + G_t + G_r}_{\text{EIRP}} - 25.26 - 20 \log R$$

$$\text{EIRP} = P_r - G_r + 25.26 + 20 \log R$$

↑
-99 dBm minimum

2.15 dB dipole antenna

$$\begin{aligned} \text{EIRP} &= -99 - 2.15 + 25.26 + 20 \log R \\ &= -75.89 + 20 \log R \end{aligned}$$

Assuming orbit altitude = 625 km

1. Direct overhead : $R = 625 \text{ km}$

$$\begin{aligned} \text{EIRP} &= -75.89 + 20 \log(625 \times 10^3) \\ &= -75.89 + 115.92 = 36.03 \text{ dBm} \\ &\approx 4008 \text{ mW} \approx 4 \text{ W} \end{aligned}$$

with 10 dB yagi (6 element)

$$\begin{aligned} P_t &= (36.03 - 10) \text{ dBm} = 26.03 \text{ dBm} \\ &\approx \underline{\underline{400 \text{ mW}}} \end{aligned}$$

2. At horizon : $R = \sqrt{(R_E + h)^2 - R_E^2} \approx 2891 \text{ km}$ $R_E \approx 6378 \text{ km}$

$$\begin{aligned} \text{EIRP} &= -75.89 + 20 \log(2891 \times 10^3) \\ &= -75.89 + 129.22 = 53.33 \text{ dBm} \\ &\approx 215 \text{ W} \end{aligned}$$

with 10 dB yagi

$$\begin{aligned} P_t &= 53.33 - 10 = 43.33 \text{ dBm} \\ &= \underline{\underline{21.5 \text{ W}}} \end{aligned}$$

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3. Assuming a 6 element yagi (10dB Ge) with 10W Pe (40dBm) gives 50dBm EIRP. At what distance will the link margin go to zero?

$$\begin{aligned} \text{EIRP} &= -75.89 + 20 \log R \\ 20 \log R &= \text{EIRP} + 75.89 \end{aligned}$$

$$\log R = \frac{\text{EIRP} + 75.89}{20}$$

$$R = 10^{\left(\frac{\text{EIRP} + 75.89}{20}\right)} \text{ m}$$

$$\begin{aligned} R &= 10^{\left(\frac{50 + 75.89}{20}\right)} \text{ m} \approx 1970153 \text{ m} \\ &\approx 1970 \text{ km} \end{aligned}$$

What elevation angle corresponds to this distance?

Without going through the derivation,

$$\begin{aligned} \text{Elevation} &= \cos^{-1} \left(\frac{(R_E + h)^2 - R_E^2 - R^2}{-2 R_E \cdot R} \right) - 90^\circ \\ &= \cos^{-1} \left(\frac{(6378 + 625)^2 - 6378^2 - 1970^2}{-2 \cdot 6378 \cdot 1970} \right) - 90^\circ \\ &= 100.27^\circ - 90^\circ \approx \underline{\underline{10.27^\circ}} \end{aligned}$$